FIRE IN CALIFORNIA'S OAK WOODLANDS

Compiled by Douglas D. McCreary, Natural Resources Specialist
University of California Cooperative Extension, 8279 Scott Forbes Road, Browns Valley, CA 95918

History of Fire

Fires Today in California

Everyone who lives in California is aware that fires regularly occur in our state and can have devastating consequences. This past year (2003) we were again reminded by the fall fire siege in Southern California that despite of our long-standing efforts to suppress and control fires, we are still at the mercy of the Mother Nature and during extreme fire weather, there is little we can do to prevent, or even contain, fires that do start. This White Paper was prepared in the aftermath of these tremendously destructive fires to provide information to landowners, resource managers, and policy makers about fire in oak woodlands. It is meant to provide a broad overview and address several limited, but important, subject areas including historical fire patterns, prescribed fire, the effects of fire on oaks and ecological processes in oak woodlands, what can be done to help prevent future fires, and what landowners can do following fire to help the land and associated resources recover. It is our hope that this paper will provide concise information about this critical subject to help a variety of people understand fire in oak woodlands and assist them in developing strategies to minimize its negative effects.

Natural Fire Frequency

Native California oaks evolved in a Mediterranean climate where natural fires burned regularly. Pavlik et al. (1991) characterize Mediterranean climates in general as fire-prone, with major fire intervals between 30-50 years in savanna, woodland, and chaparral plant communities, with major fires in forests occurring every 40-100 years. Fire is an essential element of oak ecosystems, but since the early part of the 20th century, fires have been aggressively suppressed in California, resulting in fewer escaped fires.

Research indicates that prior to European settlement in the mid-1800s, fires occurred in the northern Sierra foothill woodlands approximately every 25 years (McClaran 1986). During the decades following the Gold Rush, fires were even more frequent. Fire history research by Stephens (1997) found that in a mixed oak-pine forest (75%-25%) in El Dorado County, mean fire intervals in three study plots were approximately 8 years between 1850 and 1952 (range was from 2-18 years). The intentional use of fire by early range managers probably contributed to an increase in fire frequency.

In central and southern California coastal shrublands, fires frequencies prior to the arrival of Europeans were higher than would have occurred naturally, presumably because Native Americans regularly used fire to convert shrublands to grasslands (see below), and in the 1800s, European settlers continued this practice. There were also infrequent high intensity fires during extreme fire weather (Moritz 1997).

Native American Use of Fire

Prior to the arrival of Europeans, Native Americans used fire as a management tool (Blackburn and Anderson 1993). Woodland understories were regularly burned for a variety of reasons, including facilitating access, stimulating the growth of materials used for weaving baskets, improving habitat for game animals, making it easier to collect acorns, and killing insects that damaged acorn crops (McCarthy 1993). Frequent low-intensity woodland burning probably resulted in the creation and maintenance of cohorts of large oak trees. Repeated burning would likely have killed brush and small trees and there would have been efforts to protect large trees since they are generally the best acorn producers. Shrublands were also likely regularly burned by Native Americans in California's coastal ranges to reduce shrub cover and convert areas to grasslands (Keeley 2002). In the lower elevation valleys, repeated burning would have promoted more open savannah-like stands with widely spaced valley oaks, and a mosaic of fine-grained vegetation patches, with relatively little shrub cover. This is certainly what the earliest explorers reported seeing in the central valley of California in the early part of the 19th century (Pavlik 1991).

Fire Suppression in the 20th Century

There has been a policy of active fire suppression in California during much of the 20th century which has altered

(continued on next page)

historic fire frequency, fuel loads, and fire dynamics. That is, the significant reduction of fire as an ecosystem process has had important consequences, allowing an accumulation of fuels that had previously been consumed during regular, low-intensity fires. In addition to causing a build-up of woody vegetation in the understory, fire suppression has also promoted an increase in tree density, and some open, savannah-like woodlands converted to vegetative communities with a greater shrub component. In some locations, there have also been significant increases in dead and down woody material and an increase in "ladder" fuels connecting ground vegetation to the tree canopies. This has resulted in oak woodlands that are more susceptible to severe, crown-consuming fires today, although such large fires are not a recent phenomenon in the state, and certainly have occurred in California's shrublands for centuries (Mensing et al. 1999, Moritz 2003).

When wild fires do start in California today— especially during extreme fire weather—there is a greater likelihood that the conflagration will become so intense that tree canopies will be ignited and the trees will be consumed. Clearly weather conditions play a critical role in determining the size and scope of fires. But since California regularly experiences extreme fire weather, with strong east winds, usually accompanied by high heat and low humidity, it is not a matter of "if," but "when," such fires will start. Such weather is common in the fall when Santa Ana winds blow hot, dry wind off the desert, especially in Southern California. Fire risk is especially high because such winds occur at the end of a 6-month drought period when fuels are exceedingly dry. Fires that start during these conditions have a far greater chance of becoming large in scope. The combination of fuel loading, weather conditions, and slope of the terrain are the key components in determining the intensity of such wildfires.

The view that fire suppression in the 20th century has contributed to the likelihood of larger fires today is supported by research comparing fire regimes in Southern California, where fire suppression has been practiced for a century, to fire regimes in nearby Baja California, Mexico, where fire suppression has been largely non-existent for much of this period (Minnich and Chou 1997). The fine-grained mosaic of vegetation in Baja resulting from fires being allowed to burn has greatly reduced the average size of the fires that do start there.

Finally it is worth noting that although there has been a concerted and generally effective program of fire suppression in California in the last 100 years — at least in terms of keeping small fires small—the frequency of ignitions, at least in Southern California, has actually increased with population growth. This is because most of the fires that do start today are human-caused, either accidentally or intentionally, and it is reasonable to expect that the threat of people igniting fires will increase as the population continues to grow.

Recent Examples of Woodland Fires

There are numerous examples of wildfires in oak woodlands in the last several decades that have become large conflagrations, in part because fuel loads were so high. In 1988, there was a fire in the Sierra Nevada foothills of Nevada County called the "49er Fire." This fire started in mid-September and by the time it was through, it had burned 35,000 acres and destroyed nearly 300 structures. It burned primarily in low-elevation foothills and fuels consisted largely of oaks and chaparral. Due to the severe weather conditions and abundant fuels, the fire was out-of-control for several days, in spite of massive containment efforts.

A few years later, another disastrous fire burned in the mountains just north of San Luis Obispo. This fire, called the "Highway 41 Fire," consumed over 50,000 acres of oak woodland-chaparral habitat between Morro Bay and San Luis Obispo and destroyed homes and other property. At times the fire burned approximately 7,000 acres per hour. Headwaters of most creeks burned with an intensity that raised concerns for recovery of riparian vegetation. Furthermore, in the winter following the fire (1995), one particularly heavy storm moved thousands of tons of sediment into creeks, and then into Morro Bay, burying sensitive plant species and washing out breeding habitat for several important amphibian and fish species. Rehabilitation and restoration efforts focused on the planting of willows and sycamores to enhance habitat for sensitive terrestrial vertebrate species, and on soil stabilization and channel clearing for the fisheries.

The largest fire on record in California occurred in fall 2003 in Southern California. This was really a series of fourteen fires that burned simultaneously during a period of extreme fire weather, pushed by dry Santa Ana winds. The "Cedar Fire" was the largest, burning over 280,000 acres and destroying over 2800 structures. When all of the fires were extinguished, three quarters of a million acres had burned and nearly 4000 homes had been destroyed. While these fires were so vast (approximately one third of San Diego County alone was burned!) that many vegetation types were burned, oak woodlands and coastal sage scrub communities were some of those most severely affected.

(continued on next page)

Planned or Prescribed Fire

Some believe that extensive use of prescribed fire is necessary to reduce fuel loads to what they were in California prior to the arrival of Europeans and, consequently, the likelihood of large and destructive fires. As noted above, fire was an important management tool of Native Americans. Today, planned or prescribed fires are intentionally set so as to mimic what might naturally occur if fires were allowed to burn. However, they are set under very controlled conditions to minimize the chances of the fire escaping. In addition to reducing fuel loads, planned fires are also used to control noxious weeds, to open areas up so that forage growth is enhanced, and to promote the establishment of more desirable plant species. Minnich (2001) suggests that in chaparral communities a "fuel management strategy that maintains a patch mosaic can be accomplished through the use of planned broadcast burns of moderate size." Fuels reduction accompanying such fires could preclude a recurrence of fire for decades. Planned burning has been effectively used in a variety of oak woodland areas. Vegetation modification resulting from planned fire is probably much more effective in reducing future wildfire intensity under moderate weather conditions than under severe fire weather, since under severe conditions, almost any vegetation will burn.

However, prescribed burning is not without controversy. Examples throughout the West exist where prescribed burns have escalated to catastrophic wildfires. As a result, some resource management agencies are reluctant to use, or approve the use of, planned fire because of the risk of escape and the liability involved. Concerns about liability probably prevent the use of prescribed fire in many situations where it could effectively reduce fuels and the risks of larger fires later on.

Prescribed fires also produce considerable amounts of smoke, creating conflicts with neighboring landowners. In most locales it is necessary to get approval from the State Air Quality Control Board before starting a fire. However, the conditions that promote smoke dispersal are often not favorable for controlled burns. Many consider air-quality restrictions a bottleneck to the use of prescribed fire and hope that this conflict can somehow be rectified so that planned fire remains a viable fuels-management option.

It has also become much more difficult to conduct "safe" prescribed fires because the state's landscape has become so much more fragmented, with houses and other buildings within, or adjacent to, areas targeted for burning. These ownership patterns complicate prescribed burning plans in many areas, particularly those in wildland-urban interface areas.

As a result of concerns about the use of prescribed burning and constraints on when fires can legally be set, considerable effort currently goes into reducing fuels by means other than fire. Treatments such as hand clearing and machine chipping are commonly used, but these practices are generally more expensive than burning and there are risks associated with them as well (i.e., chainsaw injuries). The California Department of Forestry and Fire Protection (CDF) now treats almost as many acres using these practices as they do using fire. Another tool used in some locales is to graze domestic livestock to reduce fuel loads.

Ecological Effects of Fire

Direct Effects on Oak Trees

Unlike most coniferous species, oaks have evolved mechanisms to survive periodic burning. Moderate and even low-intensity fires can scorch all the leaves on woody plants. For most conifers such damage is usually lethal. Oaks, on the other hand, suffer little long-term damage from the burning of their foliage. If fires happens early in the growing season, the trees may regrow new leaves before autumn and by the end of the year it may be difficult to tell which trees were scorched in the fire. If fires occur in the summer the oaks usually will not produce a complete crop of new leaves until the following spring. Following such fires, the trees can appear dead, since all leaves are brown and brittle and the boles may be blackened. But many of these trees will survive and it is important that landowners understand this since some may want to cut these trees down, believing they will not recover. It is therefore generally a good practice to wait at least a year after the fire to determine if a tree has been killed and should be removed.

More severe fires can kill the tops of oaks if the cambium has been heated to lethal temperatures. The cambium is that area immediately under the bark where cell division and radial diameter growth occur. If the cambium has been heated so severely that it has been killed all the way around, the top of the tree will eventually die, since the apparatus that transports food within the tree has been destroyed. However, it is often difficult to tell if the cambium has been killed by merely looking at the outside of the trunk. Fires that have scorched the bole and turned it black are not necessarily hot enough to kill the cambium – especially on

(continued on next page)

larger diameter trees that have thicker bark (Plumb and Gomez 1983). This is because bark is a good insulating material and the thicker it is, the better it is at preventing heat damage underneath. However, if the fire has been hot enough to actually burn into the bark and reduce its thickness, the cambium is usually killed. One can often determine the severity of damage by cutting into and under the bark to observe the cambium. Healthy cambium is white and moist, while dead cambium is usually brown and partially dried out.

Sprouting by Oaks

Even if an oak has been girdled and the aboveground portion of the tree has been killed, most will sprout from their base the following year. Sprout-origin trees initially produce many new shoots. These sprout clumps thin out over time, although even mature trees that started as sprouts usually have multiple trunks. In general, live oaks are more vigorous sprouters than deciduous oaks, and smaller diameter trees are more likely to sprout than large diameter ones, although all California oak species will sprout. Oaks in moister areas also generally sprout better than those growing on dry sites. Many of the oak trees in California today originated as sprouts following fire and can be recognized because they usually have several main trunks. Sprout-origin trees generally grow faster than young seedlings starting from acorns. This is because they have a massive root system compared to a newly germinated acorn. As such, they have access to greater amounts of water and nutrients to support top growth.

Oak Regeneration

Some believe that fire suppression in the last century may be contributing to some of the oak regeneration problems in California today. According to this theory, frequent fires in the past may have created conditions more favorable to oak regeneration. These include eliminating competition, creating a more favorable seedbed for acorns to germinate, and reducing the habitat of wildlife species that eat acorns or seedlings. Since oaks sprout and many other plants don't, fires could give sprouting oaks a "head start" and enhance their chances of survival. Also, fuel buildup as a result of fire suppression may have created conditions unfavorable for recruitment (Mensing 1992). However, most people believe that poor oak regeneration is primarily caused by factors other than fire suppression.

Planting Oaks in Areas Where Oak Trees Have Been Killed

Even though most oaks will sprout following fire, in lower rainfall areas this is less likely. And although there is little data on the subject, sprouting may also be inhibited in areas where the fire burned extremely hot — especially where a portion of the root system was consumed. In such instances it may be desirable to plant young oaks to replace trees that were killed.

Practices to artificially regenerate oaks in California are well established (McCreary 2001). It is important to utilize plant material that is well adapted to the site (i.e., locally collected acorns), to plant acorns or seedlings at the right time of year (i.e., in the late fall or early winter when soils are moist), to make sure that the young plants are protected from damaging animals, and to control competing vegetation in the immediate vicinity of the seedlings for at least two years. Chances for success will also be enhanced by choosing favorable microsites for planting. These sites may be difficult to identify, but often one can gain some insight by looking at nearby areas where oaks are present and observing patterns where the trees have established naturally. Usually south-facing exposed ridges are much less likely to have oaks growing on them than are north-facing slopes or drainages, because soil conditions are much drier on southern aspects. And in grazed areas, oaks that have survived can often be found in locations that present some natural barrier to livestock and/or deer, such as rock outcrops or steep slopes. Mimicking these natural patterns in artificial regeneration efforts, and choosing planting sites that afford some natural protection or better environmental conditions, can often enhance success rates.

Effects on Erosion and Water Quality

In addition to the enormous costs of large wildland fires from suppression and the loss of property and possibly life, fires can also have serious negative consequences on a variety of ecosystem functions. Of significant concern is the potential for erosion after a fire, as denuded landscapes are buffeted by early winter storms. Sediment from burned slopes can clog streams and reduce water quality. And, as the recent events in Waterman Canyon in San Bernardino County (the tragic mud slides on Christmas Day 2003 that claimed 14 lives) demonstrated, there are also serious safety concerns associated with unstable soils and mud and debris flows following fire. To mitigate the likelihood of soil movement, it has been common practice since the 1940s to seed annual rye grass (*Lolium multiflorum*) onto exposed slopes and cat trails. This has been done to quickly establish a plant whose roots will theoretically help anchor the soil. The seed of annual rye has historically been used because it germinates rapidly, is relatively inexpensive, and is easy to broadcast.

However, seeding annual rye has become a controversial practice that is generally not supported by the eco-

(continued on next page)

logical restoration community (Amme 2003). Research suggests that except in unusual circumstances where fires are followed by gentle rains, seeded annual grasses are unlikely to slow erosion (Gautier and Zedler 1982), can suppress the recovery of native vegetation (Conard et al. 1991), and may promote higher rodent populations which can cause increased levels of plant browsing and predation (Griffin 1982). Annual rye also tends to produce dry, flashy fuels the following year, increasing the likelihood of a subsequent fire (Griffin 1982). Instead, it has been suggested that burned areas should either not be seeded at all, or should be seeded with mixtures including native perennials. Aside from planting a more heterogeneous, natural mixture, the addition of perennials can help establish vegetation that provides a more natural fire break, since perennials stay partially green throughout the year and consequently, are not as combustible in the summer and fall as dried-out annual plants. Today, a more common practice on roads and fire lines in burned areas is to install water bars and rolling dips to minimize erosion. In addition, rice straw is used to mulch burned slopes.

Wildfires also cause changes in soil structure that may exacerbate erosion problems. The burning of litter and organic matter can reduce infiltration and increase runoff. Extremely hot fires can also cause a waxy coating to form around soil particles below the surface. These layers repel water, increasing runoff, and can persist for years, unless the physical structure of the soil is somehow altered. On gentle slopes it is possible to break up this hydrophobic layer by hoeing or raking, but on steep terrain, this is usually not an option. In these instances, fallen logs can be strategically placed, or straw mulch can be scattered on the slopes to help reduce surface flow. Other erosion-control techniques include fiber rolls, silt fences, straw matting, and wood chips.

Effects on Range Forage

Woodland fires also greatly reduce, or entirely eliminate, range forage. In addition to the effects of fire on aesthetics and the potential for erosion, fires that burn up forage can have serious economic consequences for ranchers. Since the vast majority of oak woodlands are privately owned and the principal economic activity on these lands is livestock production (Bolsinger 1988), most fires on rangelands force ranchers to look elsewhere to obtain sufficient replacement forage to maintain their herds. Often it is not readily available, or available only at an elevated cost (McDougald et al. 1991). In addition, fires usually deplete forage production the following year, requiring additional forage supplementation.

Impacts of Wildfires on Wildlife

One of the most obvious consequences of fire in oak woodlands is the impact to wildlife habitat. Oak woodlands are one of the richest and most diverse habitat types in the state and are home to roughly half of California's terrestrial vertebrates (Tietje and Vreeland 1997). Fire has the immediate impact of changing the structural and compositional features of wildlife habitat, but this does not mean the habitat has been "destroyed." The wide range of fire types dictated by fuel loads, fuel moisture, and weather conditions produce a wide range of post-burn results. Many low- to moderate-intensity fires can actually have a net positive effect on wildlife habitat. Fire conflagrations, on the other hand, can seriously impact habitats and require years for recovery. Bigger, hotter fires destroy more of the seed base and cause a greater loss of topsoil, both of which make habitat recovery slower and more difficult. Since most severe fires occur in the late summer or early fall when acorns are maturing, they can also cause a significant loss of the mast that so many animals rely on. But low-intensity fires, including controlled prescribed fires, generally have little impact on acorn yield and can create mosaics of differing successional stages of habitat that promote plant and animal diversity.

Most scientific evidence indicates that typical oak woodland understory fires do not adversely affect the majority of terrestrial animals. In an experimental fire that burned approximately 50% of 500 acres of mixed blue oak - coast live oak woodland in central-coastal California, there was no appreciable loss of tree of shrub canopy cover (Vreeland and Tietje 2001). Although grass cover was reduced by 70% and downed wood and woodrat houses by 30%, there were no substantial or long-term negative impacts to over 150 species of birds, small mammals, amphibians, and reptiles monitored 2 years before and 4 years after the fire. This study demonstrated that many small, resident vertebrates merely go below ground during a fire and emerge unscathed once the flames have passed. Species of lizards, snakes, and most rodents can readily survive fires.

Birds are not particularly vulnerable to fire since they simply fly out of the fire area, and unless the fire occurs during the nesting season, most individuals can easily escape. Little research has evaluated the impacts of fire on invertebrates, but it is logical to assume that many insects that live above ground are susceptible to fast-moving wildfires.

Larger mammals such as deer, bear, foxes, etc., are also at risk from fast-moving fires since they can only escape by running away. This escape mechanism puts individuals at risk in

(continued on next page)

severe, fast-moving fires such as those in Southern California in 2003. In most cases, there are sufficient suitable wildlife habitat elements soon after the fire to allow the surviving smaller animals to re-occupy the site as the vegetation begins to sprout or germinate. In time, larger animals will immigrate back into the fire area also as these habitat elements are reestablished.

How a fire affects wildlife also depends on suppression methods. This is important because suppression activities can be modified. Some of the greatest ecological impacts result from bulldozer activity, including where lines are located and how big they are. These influence future erosion and silting, as well as access by cattle, motorized vehicles, hikers, bikers, and hunters. Fire fighting equipment that may have come from hundreds of miles away can also inadvertently introduce noxious weeds. For example, purple star thistle came into Santa Barbara County near Figueroa Mountain in 1993 on heavy equipment used to suppress the Marre Fire in oak woodland.

Fire suppression efforts also provide a potential avenue for the spread of Sudden Oak Death (SOD) disease. Bulldozer lines, equipment caked with soil contaminated with pathogens moved by truck or helicopter, and even the footprints of the fire fighters themselves, are all possible avenues for spreading *Phytophthora ramorum*, the agent responsible for SOD. Potentially, introduced pathogens or noxious weeds could have greater long-term effects on wildlife populations than the fire itself. However, these risks can be reduced by sanitizing equipment prior to use.

Currently, on large-scale fires, both the US Forest Service (USFS) and the California Department of Fish and Game (DFG) take the approach that it is generally not economical, or even desirable, to do anything afterwards to accelerate habitat development. An exception is if the habitat of a species that is particularly valued because it is threatened or endangered, sensitive, or of high economic value, is severely impacted. For example, an isolated population of the endangered yellow-legged frog (*Rana boylii*) occupied a mile of oak riparian habitat that was completely burned in a recent fire. Because winter flooding would likely silt-in their breeding habitat, the USFS and the US Fish and Wildlife Service captured tadpoles and moved them into a raising facility to be returned to the original site in a year or two when the habitat is again suitable (personal communication K.C. Cooper, USFS). Typically, however, with species that are widespread and not at high risk, nature will take its course and the species will recover.

A *Fire Effects Information Database* is available online through the Rocky Mountain Research Station Web site (see list at end of paper). This database provides up-to-date information about fire effects on plants and animals. It was developed at the USDA Forest Service Rocky Mountain Research Station's Fire Sciences Laboratory in Missoula, Montana. The *Fire Effects Information Database* contains general descriptions of almost 900 plant species, approximately 100 animal species, and 16 communities of plants found in North America. The emphasis of each summary is on fire and how it affects each species.

Steps landowners can take to improve wildlife habitat on burned landscapes are also listed in the Appendix.

How Will Fires Affect Oak Woodlands in the Future

The condition of California's oak woodlands today in terms of climate, fuel loads, and ignition sources suggests that large catastrophic fires will continue to occur. As stated before, it is not so much "if" as "when" these fires will take place. Wildfires are an inevitable, and ecologically important, process within oak-woodland ecosystems. People can, however, co-exist with wildfire by taking steps to reduce the adverse consequences of fires that do start. Considering fire safety in planning where homes are built is paramount and could significantly reduce property losses. Too often homes are located in areas that are vulnerable and especially difficult to protect, such as at the top of chaparral-covered slopes, which has been likened to building on top of a chimney. And increasingly, fire suppression in woodlands is made even more problematic because houses are dispersed throughout areas that were previously rural. Access to these homes is often difficult because roads are narrow and the houses are spread out. Structures are also sometimes not well identified on maps. As a result, firefighters can have difficulty even locating structures to protect.

When they can find the buildings, resources that could have been used to control a fire and establish a perimeter around it have been diverted to concentrate on defending homes, making control that much more difficult. Using planning to promote in-growth within current urban boundaries, or supporting cluster developments

(continued on next page)

where houses are located together in fire-safe locations — leaving large expanses of wildlands intact — would certainly make it easier to fight and control fires that do start. Such developments would also protect some other important ecological values, such as maintaining large expanses of undisturbed wildlife habitat, that are becoming increasingly recognized as important.

Making sure that structures are "fire-safe" could also have enormous positive benefits. There is certainly a much greater emphasis today than there was even 20 years ago on requirements that buildings be constructed out of fire-resistant materials (e.g., substituting fire resistant roofing for non-treated wooden shakes or shingles), and that combustible fuels should be cleared from close proximity to structures (Gilmer 1994). The emergence of local *Fire-Safe Councils* to promote safe construction and maintenance efforts has also raised awareness about the danger of wildfires and has resulted in significant improvements in construction and safety planning.

Finally, there is an increased awareness of how fuel loads contribute to fire severity. From the Federal Government's "Healthy Forests Initiative," to the California Fire Plan, to local *Fire-Safe Councils*, there is widespread recognition today that fuels are much greater than they were in the past, and that it is essential to reduce them in order to lessen the chances of catastrophic fires. These are certainly steps in the right direction. However, agreeing on "how" to treat vegetation is often easier said than done. Fragmentation and the increasing complexity of ownership, as well as differing management goals and philosophies of adjacent landowners, can make it extremely difficult to reach consensus about how best to reduce fuel loads. This difficulty is compounded by the accelerating costs of fuel reduction treatments, liability concerns, and a reluctance to contribute to air pollution. But we do seem to be learning more and are moving in the right direction.

Conclusions

Fires in California's oak woodlands will continue to occur and we have no recourse but to learn to live with them as best we can. However, as indicated throughout this paper, there are things we can do to minimize the negative effects of fire. We can reduce fuel loads and locate new construction in areas that are easier to protect. We can build homes with more fire-safe materials and create buffer zones around structures by clearing vegetation and other combustible materials, thus reducing the risk of property loss. And we can help restore vegetation, including oak trees, in areas that have burned. These steps will help reduce the loss of life and property that has become all too familiar. They will also help ensure that our native oak woodlands, and the myriad of values they provide, are conserved for future generations.

Appendices

Steps homeowners can take to make their property more fire-safe:

- Thin and prune vegetation within 100 feet of structures to create space where fire cannot easily spread;
- Remove "ladder-fuels" so that surface fires cannot easily burn into tree canopies;
- Use fire-safe building materials during construction (i.e., non-combustible roofing);
- Plant fire-resistant, drought-tolerant plants;
- Store firewood away from buildings;
- In rural areas, develop water sources (i.e., water storage tanks) that can be tapped into during fires.

Steps landowners can take to improve wildlife habitat on severely burned landscapes:

- Build and install nest boxes (see Gorenzel et al. 1993);
- Retain some large dead and down woody material for amphibians and reptiles;
- Retain some standing dead trees for cavity nesters (as long as they do not pose a safety hazard);
- Provide clean water in shallow containers for animals moving through property;
- Add native plants to the landscape.

How to plant oaks in areas that have burned:

- Plant either acorns or small seedlings, but make sure planting material originated from near burned area, or from an area that has similar characteristics (elevation, rainfall, etc.);
- Plant acorns or seedlings in late fall or early winter;
- Protect young oaks from damaging animals (double-walled plastic "treeshelters" have worked well for a number of oak species);
- Keep competing vegetation away from oaks (4-ft. diameter weed-free areas are recommended) for at least 2 years after planting.

Literature Cited

Amme, David. 2003. Seeding after wildfires in California: Seed with natives. Ecesis 13(4):4-5.

Blackburn, T.C. and K. Anderson. 1993. Introduction: managing the domesticated environment. Pp. 15-24 in T.C. Blackburn and K. Anderson, eds., Before the Wilderness: Environmental Management by Native Californians. Ballena Press, Menlo Park, Calif. 476 pp.

Bolsinger, Charles L. 1988. The hardwoods of California's timberlands, woodlands and savannas. USDA Forest Service Pacific Northwest Research Station Resour. Bull. PNW-148. 148 pp.

Conard, S.G, J.C. Regelbruggee and R.D. Willis. 1991. Preliminary effects of ryegrass seeding on postfire establishment of natural vegetation in two California ecosystems. Eleventh Conference on fire

(continued on next page)

and forest meteorology, April 16-19. Missoula, Mt. 8 pp.

Gautier, C.R and P.H. Zedler. 1982. Does emergency revegetation reduce or increase sediment yields from chaparral watersheds? Chap. Res. Mgmt. Newsletter. UC Coop. Ext. San Diego, CA. 8 pp.

Gilmer, Maureen. 1994. California Wildfire Landscaping. Taylor Publishing Company. Dallas, Texas. 164 pp.

Gorenzel, W.P., R.H. Schmidt, and G.A. Giusti. 1993. Want to help wildlife? Start a nest box trail! Outdoor California 54(1): 11-16.

Griffin, J.R. 1982. Pine seedlings, native ground cover, and *Lolium multiflorum* on the Marble-Cone burn, Santa Lucia Range, Ca. Madroño 29(3):177-188.

Keeley, J.A. 2002. Native American impacts on fire regimes of the California coastal ranges. Journal of Biogeography 29:303-320.

McCarthy, Helen. 1993. Managing oaks and the acorn crop. In: Before the Wilderness: Environmental Management by Native Californians. Thomas C. Blackburn and Kat Anderson, Editors. Ballena Press Anthropological papers, No. 40. pp. 213-228.

McClaran, M.P. 1986. Age structure of *Quercus douglasii* in relation to livestock grazing and fire. Ph.D. Dissertation. University of California, Berkeley. 119 pp.

McCreary, Douglas D. 2001. Regenerating Rangeland Oaks in California. University of California Agriculture and Natural Resources Communication Services Publication #21601. 62 pp.

McDougald, N.K., W.E. Frost and W.J. Clawson. 1991. Estimating the cost of replacing forage losses on annual rangeland. University of California Division of Agriculture and Natural Resources. Publication 21494. 20 pp.

Mensing, Scott. 1992. The impact of European settlement on blue oak (*Quercus douglasii*) regeneration and recruitment in the Tehachapi Mountains, California. Madroño 39(1):36-46.

Mensing, S.A., J. Michaelsen and R. Byrne. 1999. A 560-year record of Santa Ana fires reconstructed from charcoal deposited in the Santa Barbara Basin, California Quaternary Research 51. pp. 295-305.

Minnich, Richard A. 2001. An Integrated Model of Two Fire Regimes. Conservation Biology 16(6):1549-1553.

Minnich, R.A. and Y.H. Chou. 1997. Wildfire patch dynamics in the chaparral in southern California and northern Baja California. International Journal of Wildland Fire7:221-228.

Moritz, M.A. 1997. Analyzing extreme disturbance events: fire in Los Padres National Forest. Ecological Applications 7:1252-1262.

Moritz, M.A. 2003. Spatiotemporal analysis of controls on shrubland fire regimes: age dependency and fire hazard. Ecology 84:351-361.

Pavlik, B.M., P.C. Muick, S. Johnson, and M. Popper. 1991. Oaks of California. Cachuma Press, Inc. Los Olivos, Calif. 184 pp.

Plumb, T.R. and A.P. Gomez. 1983. Five Southern California Oaks: Identification and Post-fire Management. Pacific Southwest Forest and Range Experiment Station. Gen. Tech. Report PSW-71. 56 pp.

Stephens, S.L. 1997. Fire History of a Mixed Oak-Pine Forest in the Foothills of the Sierra Nevada, El Dorado County, California. Pp. 191-198, *in* Proceedings, Symposium on Oak Woodlands: Ecology, Management, and Urban Interface Issues. USFS GTR-PSW GTR-160.

Tietje, W.D. and J.K. Vreeland. 1997. Vertebrates diverse and abundant in well-structured oak woodland. California Agriculture 51(6):8-14.

Vreeland, J.K and W.D. Tietje. 2001. Numerical responses of small vertebrates to prescribed fire in a California oak woodland. pp. 269-279 *in* Proceedings of the Fifth Oak Symposium: Oaks in California's Changing Landscape. USDA Forest Service Pacific Southwest Research Station Gen. Tech Rep. PSW-GTR 184.

Internet Sources of Information on Fires in California

- http://www.cnr.berkeley.edu/forestry/curr_proj/fireabatement/fireuc.html List of fire-related publications available from the University of California (62 are listed).
- http://www.cnr.berkeley.edu/forestry/curr_proj/fireabatement/fire.html Page of the University of California's Fire Abatement Workgroup that includes list of fire publications of the California Department of Forestry and Fire Protection.
- http://ucanr.org/internal/planningi.shtml The Critical Issues Section of the 2003 PPAC Report describes how wildland fire is a critical natural resources issue in California, and discusses how the University of California Division of Agriculture and Natural Resources can help address research and education needs (pp 96-97).
- http://www.fire.ca.gov/FireEmergencyResponse/FirePlan/FirePlan.asp California Fire Plan that provides a strategy for reducing risk from wildfires.
- http://www.firesafecouncil.org/ Web address for California's Fire Safe Council that includes contact information for more than 90 local councils.
- http://www.esri.com/jicfire/fireinfo/ Information about the 2003 Southern California Fires.
- http://www.usfa.fema.gov/ United States Government Fire Administration web site.
- http://www.fireplan.gov/content/home/ Information about managing the impacts of wildfires on communities and the environment.
- http://www.firewise.org Provides documents, videos and other resources focused on firefighter safety, fire at the urban-wildland fringe, and protecting resources from loss to wildfires.
- http://www.whitehouse.gov/infocus/healthyforests/toc.html Web address for Healthy Forest Initiative.
- http://www.fs.fed.us/database/feis/ A Fire Effects Information Database that provides up-to-date information about fire effects on plants and animals.

This is a publication of the University of California Integrated Hardwood Range Management Program.

Additional copies may be obtained at http://danr.ucop.edu/ihrmp/

For more information, e-mail ihrmp@nature.berkeley.edu